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(19)

(54) STRUCTURAL MATERIALS

(71) We, FORMICA INTERNATIONAL LIMITED, a British Company of 84/86 Regent Street, London, W1A 1DL., do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to unitary structural materials comprising a combination of a thermoset plastics laminate and a water-set cementitious composition and to a process for making them.

The satisfactory bonding of a thermoset plastics laminate sheet to a water-settable composition is difficult to achieve because of the non-porous nature of the laminate surface. Furthermore, the bond between the laminate and the water-set cementitious composition can be deleteriously affected by stress variations which may arise through environmental changes in temperature and humidity. A satisfactory bonding system must produce a composite which, in use, will withstand the effects of the differing physical properties of the constituent materials, for example, dimensional stability under varying environmental conditions.

It has previously been proposed, in order to achieve satisfactory bonding between a plastics laminate and a water-settable cementitious composition to provide, for example adhesively secured studs, ribs or wire-netting on the laminate surface. When wire-netting is used it may be folded to provide a regularly crested structure. However, such modified forms of laminate are not only expensive to produce but also, because products are generally required in the form in which they are ready for use, they require a laminate manufacturer to increase the number of products available to his customers. Plastics lamiantes are most commonly bonded to solid substrates and there is a requirement for a satisfactory system of bonding laminates to water-settable compositions which requires a modification to the laminaters which is cheap to effect and may be made either by a purchaser of unmodified laminates or by the manufacturer of the laminate with an inexpensive and simple additional manufacturing step.

A unitary structural material according to this invention comprises a thermoset plastics laminate (as defined) secured to a water-set cementitious composition, the laminate sheet being secured to the cementitious composition through an intermediate porous fibrous sheet of high wet strength (as herein defined) the intermediate fibrous sheet being bonded to a preformed thermoset plastics laminate sheet by an adhesive and being keyed to the cementitious material as a result of having been embedded in the cementitious composition before water-setting thereof.

By a thermoset plastics laminate we mean a laminate, which may exhibit a decorative appearance, produced by assembling a stack of a plurality of thermosettable resin impregnated organic fibrous sheets and then applying heat and pressure to the stack whereby it is consolidated to a unitary structure and the thermosettable resin(s) cured to the thermoset state.

Preferably the surface of the laminate to which the intermediate fibrous layer is applied has a roughened surface provided, for example, by mechanical abrasion or sand-blasting of the said surface before the laminate is used in the manufacture of structural materials according to this invention.

The water-set cementitious composition may comprise any such composition, for example, plaster, inorganic particle/sodium silicate mixtures, lime or cement mortar and concrete. The composition may include reinforcing elements such as are commonly employed with cementitious compositions; chopped glass fibre strands are particularly useful reinforcements but other fibre reinforcements may be used as well as reticulate or rod reinforcements.

The cementitious composition may be a light-weight composition, for example, a foamed cementitious composition and/or include a light-weight aggregate such as vermiculite, expanded perlite, powdered fly-ash or expanded synthetic polymer beads.

The intermediate fibrous sheet may be made of either organic, for example, synthetic polymer fibres or cellulosic fibres, or inorganic, for example, glass or asbestos fibres.

The fibrous sheet has a high wet strength (i.e. its tensile strength when completely wetted by water is 20% or more of its dry tensile strength) and a high resistance to moisture over long periods. The structural materials of this invention may remain wet over extended periods whilst the cementitious composition sets and may be subject to the effects of moisture whilst in use, the plane of connection between the surface components and the cementitious composition being somewhat susceptible to attack by moisture.

The intermediate fibrous sheet may take one of a number of forms provided that it is porous thereby to take-up sufficient adhesive to effect a satisfactory bond between it and the surface of the laminate and of such a nature in the parts of which are adhesive-free that the cementitious composition, when its wet-state will either or both penetrate into the body of fibrous sheet and flow around and between the fibres on the surface thereof. The fibrous sheet must provide a vast number of sites for the establishment, on setting of the composition, of a mechanical key between the fibrous sheet and the cementitious composition. The fibrous sheet should also be able to take up sufficient adhesive to effect a satisfactory bond between it and the surface of the laminate.

The surface of the fibrous sheet adjacent the cementitious composition is preferably non-smooth. It may be a woven material and, more particularly, a coarsely woven material. Thus, wholly or in part, the key sites of a woven fibrous sheet are provided by the interstices between the fibres. Thus the water-settable cementitious composition penetrates into the interstices of the fibrous sheet when the sheet is embedded therein and a strong key is provided when the composition sets.

We prefer, however, to employ bonded non-woven materials of the kind in which adjacent fibres are bonded one to another and more especially those of homogeneous structure, i.e. of non-layered structure. Non-woven materials made up from joined but separately laid layers are unlikely to possess sufficient internal bond strength for the purposes of this invention. Non-woven synthetic polymer or cellulose materials may be used. Thus in the case of non-woven fibrous sheets the key sites are provided wholly or in part by the nap or woolly nature of the surfaces of such sheets. The nap fibres become intimately associated with the water-settable cementitious compositions when the fibrous sheet is embedded therein and are retained thereby to provide a strong key when the composition sets.

The adhesive used to adhere the fibrous sheet to the surface of the laminate may be of any kind provided it provides an adequate and durable bond and is resistant to the effects of moisture. We prefer, however, to use an adhesive selected from phenol-formaldehyde resins, urea-formaldehyde resins, epoxy resins and polyvinyl alcohol resin compositions.

Preferably, the fibrous sheet is co-extensive with the surface of the laminate and bonded thereto over substantially the entire co-extensive area.

Although satisfactory materials according to this invention comprise merely a laminate with an adhesively secured intermediate fibrous sheet and a water-set cementitious composition, they may also include a discontinuous primer layer between the intermediate fibrous web and the water-set cementitious composition, the primer, for example, a polymeric latex or an epoxy resin, having been in the unset or uncured state when the fibrous sheet is embedded in the water-settable cementitious composition. In order not to obscure the key sites on or at the opposite surface of the intermediate fibrous sheet the primer layer should be applied at low coating weights and should be discontinuous. The presence of such a primer enhances the ability of the fibrous layer to accommodate stresses that may occur in the structural material due to dimensional changes in the components and such modified materials according to this invention thus have particular application in situations where the faces of the structural material are exposed to differing environments, for example, when they are used as tunnel linings.

This invention further provides a process for manufacturing the structural materials, which process comprises (i) adhesively bonding one surface of a high wet-strength (as hereinbefore dfined) intermediate porous fibrous, sheet to a surface of a preformed thermoset plastics laminate sheet (as defined herein), and (ii) embedding the opposite surface of the intermediate porous fibrous sheet in a water-settable cementitious composition and setting the cementitious composition,

the steps (i) and (ii) being carried out in either order.

In this process the adhesive may be applied to the laminate surface, to the fibrous sheet or both and any suitable method may be used to apply the adhesive to these components; for example, the adhesive may be applied by spraying, brushing or roller coating. Heat may be applied in the application of the adhesive but only light smoothing pressure preferably should be used; the application of excess pressure may cause the adhesive to extend through the body of the fibrous sheet to the opposite surface thereof and thus reduce the effectiveness of the fibrous sheet in providing key sites for the cementitious composition.

In a preferred process for preparing the structural material of the invention a fibrous sheet is adhesively bonded to the non-decorative surface of a decorative thermoset plastics laminate and the composite board so formed then positioned, after the adhesive has been cured or set, with the decorative surface downwards on or in a suitable former, mould or jig. A cementitious composition in the fluid state is then applied to the exposed, opposite, surface of the fibrous sheet adhesively bonded to the laminate to form the composite board, optionally with the aid of vibratory means to ensure compaction of the composition and then allowed, or caused, to set.

In an alternative technique the fluid cementitious composition is poured into a mould and a laminate carrying a fibrous sheet bonded to one side by means of a cured adhesive is positioned thereon with the fibrous sheet in contact with the cementitious composition and the composition then allowed, or caused, to set.

If it is desired to prepare a structural material having a core comprising a water-set cementitious composition surfaced on both of its major faces with a decorative plastics laminate, then such a material may be prepared by a "lost shuttering" technique. In such a technique, for example, two composite boards, each comprising a laminate with a fibrous sheet bonded to one side by means of a cured adhesive, are positioned in spaced apart relationship with their fibrous sheet surfaces facing towards each other, a fluid cementitious composition is then caused to occupy the space bounded by the boards and suitable edge closing means and then the composition is allowed, or caused, to set. By means of such a technique a structural material, in panel form, useful as partition panelling and exhibiting a decorative effect on both of its major surfaces is conveniently and economically produced.

The following Example illustrates the invention.

A conventional thermoset decorative plastics laminate comprising an alpha cellulose paper overlay and a printed paper decorative layer each impregnated with a thermoset melamine-formaldehyde resin composition, and a core layer comprising a plurality of kraft-paper sheets impregnated with a thermoset phenol-formaldehyde resin composition was provided on its sanded rear surface with a coating of a commercially available epoxy resin/hardener mix. The coating was prepared by mixing epoxy resin DER 331 with hardener 185 M in accordance with the instructions of the supplier, Casa Chemicals Limited, and applied by means of a hand-roller to give a coating weight of about 150 g/m² on the laminate.

A sheet of non-woven single-layer fabric having a weight of about 60 g/m² and comprising about 60% by weight viscose rayon, 20% by weight nylon and 20% by weight polyester fibres and purchased under the designation S 503 W from Bonded Fibre Fabrics Limited, co-extensive with the laminate was then positioned upon the epoxy resin coated surface and the assembly lightly pressed and hand-rolled to bring the fabric into intimate contact with the resin but to leave the exposed surface of the fabric substantially resin-free. The composite, thus formed, was set aside to allow the resin to cure and adhesively bond the fabric to the surface of the laminate.

The composite after curing, was then positioned with the fabric sheet uppermost in a mould and a discontinuous coating of an SBR co-polymer latex (DL 460 supplied by Casa Chemicals Limited) was applied to the fabric sheet, by means of a ribbed roller, at an application rate of about 0.16 litres/m². As soon as possible thereafter (i.e. before the latex had set) a water-settable cementitious composition comprising the following parts by weight:

30 parts portland cement
12 part sand
9 parts water
¼ part of a commercial air entraining agent
3 parts of alkali-resistant chopped strand glass fibre

was applied to the latex treated layer and the assembly left in the mould to set for 36 hours and then left to cure for three weeks in high humidity conditions.

After curing a structural material having a decorative thermoset plastics laminate

firmly and durably bonded to a water-set cementitious base was obtained and the materials showed no evidence of delamination after subjection to tests involving its exposure to cyclic variation in environmental conditions.

The water-settable cementitious compositions utilised in the process of this invention and the water-set cementitious materials derived therefrom may be of one of a large number of kinds (in particular the viscosity of the water-settable compositions may vary considerably) and it is thus necessary, by experimentation to determine which of the fibrous sheets within the scope of this invention is best suited to any given cementitious composition or condition thereof or to make such modifications to the condition of the cementitious composition as may be required for any particular fibrous sheet.

WHAT WE CLAIM IS:—

1. In a unitary structural material comprising a thermoset plastics laminate sheet (as defined herein) secured to a water-set cementitious composition, the improvement wherein a preformed thermoset plastics laminate sheet is secured to the cementitious composition through an intermediate porous fibrous sheet of high wet strength (as hereinbefore defined), the intermediate porous fibrous sheet being bonded to the preformed thermoset plastics laminate sheet by an adhesive and being keyed to the cementitious material as a result of having been embedded in the cementitious composition before water-setting thereof.

2. A structural material as claimed in Claim 1, wherein the intermediate fibrous layer is a coarsely woven sheet material and the fibres thereof are selected from inorganic fibres, synthetic polymer fibres and cellulosic fibres.

3. A structural material as claimed in Claim 1, wherein the intermediate fibrous layer is a bonded non-woven sheet material of homogeneous non-layered structured and the fibres thereof are selected from inorganic fibres, synthetic polymer fibres and cellulosic fibres.

4. A structural material as claimed in any one of the preceding claims, wherein the adhesive is selected from phenol-formaldehyde resins, urea-formaldehyde resins, epoxy resins and polyvinyl alcohol resin compositions.

5. A structural material as claimed in any one of the preceding claims, wherein the water-set cementitious composition is selected from plaster, inorganic particle/sodium silicate mixtures, lime mortar, cement mortar and concrete.

6. A structural material according to any one of the preceding claims, wherein a discontinuous layer of a polymeric latex or epoxy resin is provided between the water-set cementitious composition and the fibrous sheet.

7. A structural material according to any one of the preceding claims, wherein the intermediate fibrous sheet is co-extensive with the surface of the laminate sheet to which it is bonded.

8. A structural material according to any one of the preceding claims which comprises a water-set cementitious composition, the opposed surfaces of which are each keyed to one surface of an intermediate fibrous sheet and each intermediate fibrous sheet is adhesively bonded at its opposite surface to a thermoset plastics laminate sheet.

9. A unitary structural material comprising a thermoset plastics laminate sheet (as defined herein) a coherent non-woven porous fibrous sheet of high wet strength (as hereinbefore defined) comprising polymeric fibres adhesively bonded to one surface of the laminate sheet by means of a thermoset resin adhesive and having its opposite surface substantially free of said thermoset resin adhesive but carrying a light weight discontinuous coating of a polymeric latex, and a water-set cementitious composition keyed to the said latex coated surface of the fibrous sheet.

10. A unitary structural material comprising a pair of thermoset plastics laminate sheets as defined herein, a first porous fibrous sheet of high wet strength (as hereinbefore defined) having one surface thereof adhesively bonded to one surface of one of the laminate sheets and a second such fibrous sheet having one surface thereof adhesively bonded to one surface of the other laminate sheet, at least the other surfaces of the fibrous layers being substantially free of adhesive and a water-set cementitious composition having opposed surfaces keyed to the said other surfaces of the fibrous layers.

11. A structural material as claimed in any one of the preceding claims, wherein the water-set cementitious composition comprises reinforcements selcted from fibres, rods and reticulated materials.

12. A structural material as claimed in any one of the preceding claims, wherein the water-set cementitious composition comprises a foamed composition.

13. A structural material as claimed in any one of Claims 1 to 12, wherein the water-set cementitious composition comprises a light-weight aggregate selected from vermiculite, expanded perlite, powdered fly-ash and expanded synthetic polymer beads.

14. A unitary structural material substantially as described in the foregoing Example.

15. A process for making a unitary structural material comprising a thermoset plastics laminate sheet (as defined) secured to a water-set cementitious composition, which process comprises the steps of (i) adhesively bonding one surface of a high wet-strength (as hereinbefore defined) intermediate porous fibrous sheet to a surface of a preformed thermoset plastics laminate sheet as defined herein, and (ii) embedding the opposite surface of the intermediate fibrous sheet in a water-settable cementitious composition and setting the cementitious composition, the steps (i) and (ii) being carried out in either order.

16. A process according to Claim 15, wherein a homogeneous non-layered bonded non-woven sheet or coarsely woven sheet is used as the intermediate fibrous sheet.

17. A process according to either of Claims 15 and 16, wherein the surface of the laminate sheet is roughened before the intermediate fibrous sheet is adhesively bonded thereto.

18. A process according to any one of Claims 15 to 17, wherein a thermosetting resin is used to bond the intermediate fibrous sheet to the laminate sheet.

19. A process according to any one of Claims 15 to 18, wherein an adhesive is applied to one surface of the laminate sheet and the intermediate fibrous sheet is contacted with the adhesive with the application of presure sufficient to effect said bonding but insufficient to cause the adhesive to penetrate through the body of the intermediate fibrous sheet to the opposite surface thereof.

20. A process according to any one of Claims 15 to 18, wherein an adhesive is applied to one surface of the intermediate sheet and said surface is contacted with a surface of the laminate sheet with the application of pressure sufficient to effect said bonding but insufficient to cause the adhesive to penetrate through the body of the intermediate fibrous sheet to the opposite surface thereof.

21. A process according to any one of Claims 15 to 20, wherein a light-weight discontinuous coating of a polymeric latex or epoxy resin is applied to said opposite surface of the intermediate fibrous sheet and the coated opposite surface is embedded in the water-settable cementitious composition before the coating is set or cured.

22. A process for making a unitary structural material comprising a decorative thermoset plastics laminate sheet (as defined herein) secured to a water-set cementitious composition, which process comprises adhesively bonding with a thermoset resin the non-decorative surface of the decorative laminate plastics sheet to one surface of an homogeneous non-layered non-woven intermediate porous fibrous sheet of high wet strength (as hereinbefore defined) comprising bonded polymeric fibres whilst employing pressure sufficient to bring the said surfaces into firm contact but insufficient to cause the resin to penetrate through the body of the intermediate fibrous sheet to the opposite surface thereof, curing the thermosetting resin, employing the laminate sheet as an outer component of a mould, filling the mould with a water-settable cementitious composition to bring said composition into contact with said opposite surface of the intermediate fibrous sheet and setting the said cementitious composition.

23. A process for making a unitary structural material substantially as described in the foregoing Example.

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